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(56) Documents cited

GB 1170420	GB 1074971	GB 1074898
GB 1074896	GB 1074893	GB 1074892
GB 1074851	GB 1030483	GB 0879489
GB 0829614	GB 0795510	GB 0609060
US 4353069		

(58) Field of search
H1Q

(54) Improvements in and relating to the absorption of electromagnetic radiation

(57) Microwave reflectance of a material is reduced (and absorption increased) by forming parallel closely spaced apart grooves in the surface of the material and coating the grooved surface with a thin coating of a semiconductor material such as Silicon or Germanium, with or without a dopant such as Arsenic.

The coated grooved surface can be rendered smooth by using an infill material of low dielectric constant such as a low density polymer foam.

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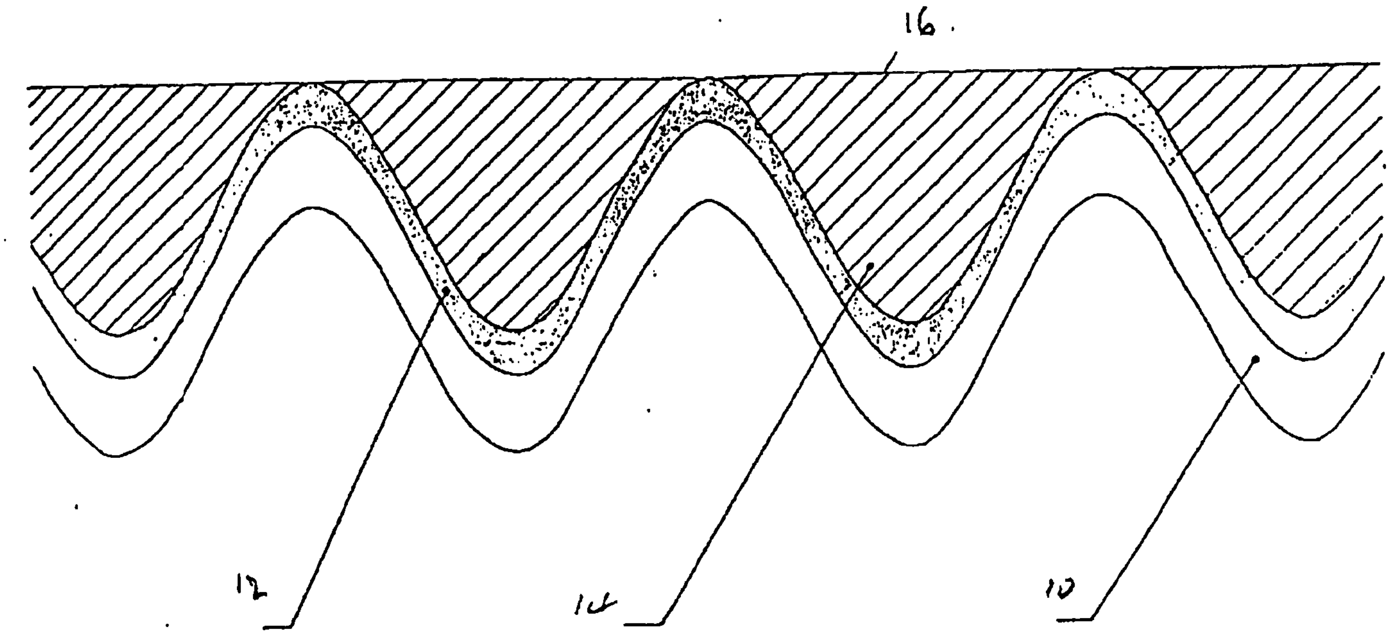
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SPECIFICATION

Improvem nts in and relating to the absorption of electromagnetic radiation

Field of invention

This invention concerns the absorption of electromagnetic radiation and particularly microwaves such as are used in microwave radar installations.

Background to the invention

There are situations in which it is desirable to reduce the radar reflectance of an object and to this end the surface of the object is covered or coated with a material which is adapted to absorb micro-wave energy so as to reduce the amount of energy reflected from the surface when impinged by a microwave pulse.

One application for such material is in the production of a radio frequency anechoic chamber to permit microwave antenna measurements to be performed. The aim of such a chamber is to simulate 'free space' conditions albeit in a confined indoor environment, by reducing reflections from the room boundaries.

A second application for such material is in the covering of installations, buildings, craft and equipment and vehicles to reduce the chance of detection of such by enemy radar.

It is an object of the present invention to provide an improved form of material to achieve the above.

Prior Art

There are basically three types of absorbent material in use today namely:

1) a material based on the principle of matched magnetic permeability and dielectric constant

2) resonance absorption material usually a quarter wavelength thick operating over a relatively narrow frequency band and

3) materials which are broad band in response and the impedance of which across the thickness of the material varies from that of free space to that of the medium over an appreciable thickness in terms of the wavelengths of radiation likely to be incident thereon.

Summary of the invention

According to the present invention a microwave absorbing material is constructed from

1) sheet substrate material having formed in one face thereof a plurality of regularly spaced and similarly shaped protrusions so as to form a rectilinear lattice of grooves, and

2) a layer of semiconductor material on the grooved surface of the substrate.

Typically the substrate is a metal sheet and preferred semiconductor materials are germanium and silicon.

Preferably the coating of semiconductor material is of substantially uniform thickness so that the semiconductor coating itself follows the shape and configuration of the protrusions in the surface of the substrate.

Absorption of microwaves is noticed at or around 2.5 GHz if the semiconductor material is intrinsic germanium. The frequency at which absorption is most noticeable increases if the germanium is lightly doped.

If intrinsic silicon is used the frequency at which absorption is most noticeable occurs at or around 1.5 MHz. Relatively high doping levels in the silicon raises this frequency to frequencies in the microwave region. A typical dopant is arsenic.

By utilising deep troughs and small pitch between protrusions, the coated substrate surface is found to absorb over a wide range of frequencies.

In addition to varying the depth of the grooves and the pitch of the protrusions, the bandwidth to the surface can be controlled by appropriate choice of coating material. If crystalline semiconductor material is used for the coating material then a more sharply defined frequency response is obtained than if amorphous semiconductor material such as amorphous silicon is used. Consequently if wide bandwidth is required, amorphous semiconductor material is utilised for the coating.

It is believed that the absorption characteristic noted of these materials represents a redistribution of energy, the metallic substrate surface representing a perfect conductor so that no incident energy is transmitted into the material of the substrate.

Theory relating to so-called Floquet waves suggests that in a perfectly conducting grating the attenuation or apparent absorption of a diffracted wave in a diffraction grating or similar is attributed to a coupling of some of the incident energy into leaky surface waves which propagate on the periodic surface of the grating. In priciple even very slight surface roughness can stimulate coupling if the incident plane wave has transverse magnetic polarisation (ie there is magnetic field component parallel to the axis of propagation). The absorption characteristic is also observed for TE polarisation but here it is only observed when the surface is a deeply modulated grating ie when the modulation depth is comparable with wavelength.

The present invention provides for the coating of a grooved substrate surface which can be likened to a diffraction grating, with a semiconductor material which possesses complex permittivity at the frequencies of the radiation which is to be absorbed by the surface so that resonances occur in the surface.

From the work undertaken by S L Chuang and J A Kong and detailed in an article entitled 'wave scattering and guidance by dielectric wave guides with periodic surfaces' in the Journal of the American Optical Society Vol. 73, No. 5 May 1983, the quanta of the resulting oscillation in the surface plasma of the material is referred to as a plasmon. A requirement for plasmon generation is that the permittivity of the material should be complex and it appears that for this condition to occur the imaginary part of the permittivity js/w (where s is the conductivity of the material and w the angular frequency) should be comparable with the real part of the permittivity. If either part of the permittivity dominates then the material is either a dielectric or a conductor and the plasmon eff ct is not observed.

If appears that semiconductor materials possess

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complex permittivity at frequencies in the microwave region and doping the materials allows for variation of the frequency at which the plasmon effect is most likely to be observed.

The invention will now be described by way of example with reference to the accompanying drawing in which the single figure is a cross-section to an enlarged scale through one embodiment of the invention.

Referring to the drawing, a metal or similar material having conducting properties serves as a substrate and depending on the nature of the material can either be formed with two-dimensional corrugations so as to form an egg tray-like structure or may be a solid sheet of material one face of which is formed with a regular pattern of protrusions arranged in rows and columns. In the example shown in the drawing each protrusion is assumed to have a solid sinusoidal form and one such protrusion is designated by reference numeral 10.

Overlaying the protrusions such as 10 is a semiconductor film of the order of 1 to 10 microns thick. This film is designated by reference numeral 12 and is typically doped silicon.

Since the material is intended to form the outer skin of an object, it may be desirable to remove the surface roughness created by the protrusions and to this end the troughs and valleys between the protrusions may be filled with a low dielectric constant infill material such as a low density polymer foam shown at 14. Where this type of material forms a skin 16 during curing, the outer skin 16, which just touches the peaks of the coated protrusions, will form a smooth outer surface.

The production of a smooth outer surface may be important for aerodynamic reasons or simply to facilitate in cleaning the surface.

CLAIMS

1. Microwave absorbing material constructed from:

i) sheet substrate material having formed in one face thereof a plurality of regularly spaced and similarly shaped protrusions so as to form a rectilinear lattice of grooves, and

ii) a layer of semiconductor material on the groove surface of the substrate.

2. Microwave absorbing material as claimed in claim 1, wherein the substrate is metal.

3. Microwave absorbing material as claimed in claim 1 or 2, wherein the semiconductor material is germanium or silicon.

4. Microwave absorbing material as claimed in claim 1, 2 or 3, wherein the coating of semiconductor material is of substantially uniform thickness so that the semiconductor coating itself follows the shape and configuration of the protrusions in the surface of the substrate.

5. Microwave absorbing material as claimed in any of the preceding claims, wherein the semiconductor material is doped with one or more impurities.

6. Microwave absorbing material as claimed in claim 5, wherein the dopant is arsenic.

7. Microwave absorbing material as claimed in any of the preceding claims, wherein the protrusions are separated by deep troughs and the spacing between protrusions is small.

8. Microwave absorbing material as claimed in any of the preceding claims, wherein crystalline semiconductor material is used for th coating material.

9. Microwave absorbing material as claimed in any of claims 1 to 7, wherein amorphous semiconductor material is utilised for the coating material.

10. Microwave absorbing material comprising a substrate having a finishing surface coated with a semiconductor material which possesses complex permitivity at the frequencies of the radiation which is to be absorbed by the surface, so that resonances occur in the surface.

11. Microwave absorbing material as claimed in any of the preceding claims, wherein valleys between the protrusions are filled with low dielectric constant infill material.

12. Microwave absorbing material as claimed in claim 11, wherein the infill material is a low density polymer foam.

13. A method of reducing microwave reflectance of a surface comprising the steps of

(a) forming parallel grooves in the said surface, and

(b) coating the grooved surface with a semiconductor material.

14. A method as claimed in claim 13, wherein the semiconductor material is silicon or germanium, with or without a dopant.

15. A method as claimed in claim 13 or 14, wherein the grooved semiconductor coated surface is rendered smooth by filling the grooves with a low dielectric constant infill material.

16. A method as claimed in claim 15, wherein the infill material is a low density polymer foam.

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